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SAFETY IN MARINE TRANSPORTATION

The Bureau's activities having a bearing on safety requirements for ship construction, equipment, cargo, and stowage, and on aids to navigation, have included a considerable range of subjects, some of which are briefly indicated below. Further items thereon will be given in succeeding issues. The projects or tests were undertaken mainly at the request or with the cooperation of the Bureau of Navigation and Steamboat Inspection, the Bureau of Lighthouses, the United States Shipping Board, and groups of marine underwriters.

*Fire resistance in ship construction.*—The use of steel in hulls, decks, and bulkheads, while effecting a decided increase in safety compared with wood construction, would not as such be expected to prevent the occurrence of disastrous fires to any greater extent than incombustible walls, partitions, columns, and floors in buildings. In both cases the spread of fires in combustible furnishings, trim, and contents must be restricted by vertical and horizontal barriers. Many measures accepted as necessary in building construction have not been applied in the construction of ships, mainly on account of added weight

and cost. Recent developments in light-weight incombustible or fire-retardant materials have overcome these objections to a considerable extent.

The construction of fire-resistive bulkheads transversely across the ship has received recognition in recent years as essential in restricting horizontal spread of fire. According to the regulations adopted by the International Convention for the Safety of Life at Sea, these are required to be spaced at intervals not exceeding 40 meters (131 feet), and to be effective as a barrier for 1 hour against fires producing temperatures of 815° C. (1,500° F.) at the bulkhead. Uninsulated steel bulkheads have been advocated for acceptance under this requirement, although obviously not meeting it because of ready transmission of heat through the metal. The results of fire tests as well as construction requirements have indicated, however, the desirability of incorporating the steel bulkhead as a part of the construction, with incombustible heat-insulating materials applied on both sides. For the 1-hour requirement, the total thickness of such materials need not exceed 2 inches and the weight need not be greater than 10 pounds per square foot. In building construction, fire barriers of comparable importance

would be required to restrict the spread of severe fires for 4 hours. With proper choice of materials this can be effected with a thickness of 4 to 5 inches and weight of 20 to 30 lb./ft.<sup>2</sup> As applied in ship construction the hull, decks, longitudinal bulkheads, and intersecting pipe lines would need insulation for a foot or two on each side of such bulkhead to prevent transmission of fire from heat conduction through the metal. Constructing intermediate longitudinal and transverse fire-resistive bulkheads and cabin partitions is considered desirable as an aid in further restricting the spread of fire. On account of limitations in thickness and weight, the fire resistance that can be practically attained for them would be in the range one-half to one-fourth hour as gauged by the standard fire-testing procedure for fire partitions. Even so, as built of incombustible or fire retardant materials they would serve acceptably in confining the fire until detected and extinguished with the equipment provided.

Openings in the main fire-resistive bulkheads need protection with automatically closing or self-closing fire doors. Stairways, particularly those communicating between more than two decks, need fire-resistive enclosures with lighter self-closing fire doors in the openings. The number and location of these stairways should be such as to afford egress to relatively safe areas in case of fire. Fire stopping the spaces between the deck and bulkhead plates and their linings at suitable intervals will prevent rapid spread of fire through such concealed channels.

Because of weight limitations, deck construction cannot be given as high a degree of fire resistance as floors in fire-resistive buildings. Nevertheless, to judge from results of fire tests with unprotected and protected welded steel floors, protection comparable with that given by one-hour bulkheads is obtainable with incombustible or fire-retardant linings over the beam flanges. These should be one-half to one inch thick, combined with an incombustible top finish over the deck plate of comparable thickness. These linings and finishes would replace the combustible boards and floor covering otherwise used in spaces occupied by passengers and crew. Mastics with low combustible contents and excellent strength, bonding, and wearing properties are now obtainable at moderate cost. They can serve as the

finished wearing surface or as a base for the same.

**Fire-retardant treatments.**—The general methods for treating wood to reduce its flammability involve impregnation with chemicals under pressure. No treatment has been developed that has the desired permanence as exposed to the weather, without protective coatings, but for interior use a number of them have been in practical use for the past 30 years or more. Specifications, inspection, and tests can be applied that will give fair assurance of obtaining a required fire-retardant effect. A number of other requirements must be met by the material, including freedom from unduly corrosive effects on metal, unduly poisonous chemicals, hygroscopic chemicals, and surface discoloration. A full treatment increases the weight of the wood about 15 percent and the cost of hardwood finishing lumber about 100 percent. Where combustible materials are prohibited by building ordinances, the product has found considerable application for finish flooring and interior trim, although in recent years displaced to some extent by metal trim and composition floor finishes.

Surface treatments of wood have only minor value in decreasing the flammability, on account of the thinness of the protecting coating. Ordinary oil paints with a relatively high mineral pigment content have been found as effective as so-called "fire-retardant" paints.

Draperies and curtains can be satisfactorily flame-proofed by spraying or dipping, using a number of chemical mixtures. A borax-boric acid treatment developed for treating theater scenery has been found very effective, and the cost of the chemicals is relatively small. Such treatments must not deteriorate the fabric nor cause change in color or luster. The ordinary treatments are not permanent under laundering, although a treatment has been developed for cotton goods that gives fair resistance from this standpoint.

Satisfactory heat-insulating and sound-absorbing media can now be obtained of incombustible materials, and some of the combustible materials can be treated with admixtures, surface coatings, or veneers to reduce the flammability.

**Cargo and stores.**—The properties considered hazardous include low flash, fire, and boiling points for liquids, low ignition temperature, high flammability, and susceptibility to

spontaneous heating, liberation of oxygen, and detonation. Tests for such properties have been made of a wide range of materials submitted for ship cargoes and stores, necessitating in some cases extended experimental inquiry, among which may be mentioned the work on the effect of heat on celluloid (Bureau of Standards Technologic Paper no. 98, now out of print, but available at many technical libraries) as well as the heating and ignition tests with jute (Monograph, National Fire Protection Association, 1934).

**Fire detection.**—According to an Act of Congress, all vessels more than 150 feet in length contracted for after June 30, 1916, which are provided with staterooms or other sleeping quarters for passengers, are required to be equipped with automatic fire-detecting systems for all spaces not readily open for inspection. In case of fire these detecting devices must give audible and visible alarm signals at the bridge and other points where a continuous watch is maintained. This constituted a considerable advance in safety requirements over those of many other maritime nations. Under this requirement tests have been made of the thermostats and other thermosensitive elements employed. The general designs of various systems have also been studied. As a result of these tests decided improvements have been made in sensitivity and reliability of operation of these devices, so that it is now possible to receive positive warnings of a fire at an earlier stage than formerly, and there is less likelihood of failure.

**Motion-picture projection.**—The showing of nitrocellulose motion-picture film was formerly prohibited on ships of United States registry. The small range in subjects obtainable with the slow-burning film and the difficulty experienced by inspectors in distinguishing between the two types led to the adoption of safety measures that enabled the flammable film to be shown. Recommendations were drawn up for properly designed and vented projection booths, and examinations made of motion-picture projectors for needed safety features. While it is more difficult to obtain a desired degree of safety on shipboard than in theaters on account of the use of portable booths and screens, the records show no instance of fire or jeopardy to life resulting from the showing of motion pictures during the 12 years that these regulations have been in effect.

#### FIELD INTENSITY AT RADIO BROADCAST FREQUENCIES

During the past three years graphical records of the field intensity of over 300 broadcasting stations in the United States and Territories have been made at the Bureau's receiving station at Meadows, Md., near Washington, D. C. The method used for recording the field intensity was developed at the Bureau several years ago. The data obtained in this way were analyzed to determine the diurnal variations of the received intensity of broadcasting stations at various distances from the transmitting antennas. The data were also analyzed to determine the variation of received intensity as a function of the distance from the transmitter for day-time and night-time transmissions. As reported in RP752 in the December number of the Journal of Research, the maximum sky-wave field intensities at night are received from stations at a distance of about 600 kilometers, or 375 miles. A theory of the propagation of radio waves in the upper atmosphere was developed to explain the data. The principal conclusion of the paper, aside from the presentation of quantitative data on sky-wave field intensities, is that the variation with distance of the field intensities at night is determined primarily by the radiation characteristics of the transmitting antennas in the vertical plane.

#### CALIBRATION OF THE BUREAU'S LINE STANDARDS OF LENGTH

The National Bureau of Standards is the custodian of the standards of length in the United States. Comparisons have been made between the National Prototype Meter No. 27 and the working standards used in routine comparisons made at the Bureau when length standards are submitted for test by State authorities, college and research laboratories, manufacturers of precision instruments, and others. Research Paper No. 743 in the December Journal of Research describes some of these precision comparisons of the laboratory meter bars with Meter No. 27. Calibrations of the subintervals of one of the meter bars, and comparisons and calibrations of decimeter bars are discussed in detail. A study was also made of the precision of the work. The report shows that the basis of length measurements in this country, Meter No. 27, is apparently the same, relative to the International Prototype Meter, as it was more than 40 years ago, to about a part in 10,000,000.

#### GROUND EFFECT OF WIND-TUNNEL TESTS OF VEHICLE MODELS

In studying the aerodynamic characteristics of automobile models in the wind tunnel the ground is often represented by a ground plane, or stationary platform, extending entirely across the air stream. A second method consists in testing two models which are exact duplicates or images, wheel-to-wheel, in the free air stream. Neither method can be considered representative of full-scale conditions when a vehicle is moving along the ground. In the case of the ground-plane method there is no relative motion between the model and the ground plane. From a theoretical standpoint the image method should be representative of full-scale conditions with regard to relative motion, but this has not been demonstrated experimentally. An experimental comparison of the ground-plane method and the image method has been made at the Bureau and is reported in RP748 in the December Journal. Concordant drag measurements were obtained by the two methods when the leading edge of the platform in the ground-plane method was faired and the test position was two model lengths behind the leading edge.

#### AIR FORCES AND YAWING MOMENTS FOR THREE AUTOMOBILE MODELS

The lift, longitudinal force, cross-wind force, and yawing moment for three automobile models having substantially different body shapes were determined by means of wind-tunnel measurements. The measurements were made for various angles of relative wind between 0 and 180 degrees. Estimates based on the model measurements indicate that when an automobile of conventional body shape, geometrically similar to the model used in the tests, is driven at the speed of 50 miles per hour in a 30 mile per hour quartering wind the forces and moments of the following order of magnitudes may occur: Lift, decreasing the traction, 400 pounds; longitudinal force opposing the motion of the car, 230 pounds; lateral force pushing the car sidewise, 350 pounds; yawing moment tending to turn the car off the road, 550 pound-feet. For a moderately stream-lined automobile the forces and moments, under the same conditions of wind speed and car speed, are estimated to be: Lift, 340 pounds; longitudinal force, 90 pounds; lateral force, 170 pounds; and yawing moment, 770 pounds-feet.

Some experiments on the use of fins to reduce the yawing moment were

included in the tests, more complete results of which will be found in the December number of the Journal of Research (RP749).

#### ISOLATION OF NONANAPHTHENE FROM OKLAHOMA PETROLEUM

A nonanaphthene boiling at 136.7° C. has been isolated in a nearly pure condition from an Oklahoma petroleum. The work, which is described in the December Journal (RP745), is part of an investigation in progress at the Bureau on the separation, identification, and determination of the constituents of petroleum—listed as research project no. 6 of the American Petroleum Institute.

The isolated nonanaphthene belongs to a general class of saturated monocyclic petroleum hydrocarbons, called naphthenes, having the empirical formula of  $C_9H_{18}$ . It is one of a great number of naphthenes having the formula of  $C_9H_{18}$ , but due to the large number of possibilities it is difficult to determine which nonanaphthene it is. Its physical properties, including boiling point, freezing point, density, refractive index, heat of fusion, and critical solution temperature in aniline, have been determined. These, together with its chemical behavior, identify the compound as a derivative of cyclopentane. Of the known cyclopentane derivatives containing nine carbon atoms, the properties of the nonanaphthene from petroleum are most similar to those of dimethylethylcyclopentanes. While its behavior on distilling and on freezing is good evidence that it is a single substance, it might possibly be a mixture of isomers of the constant boiling, constant freezing type.

The compound was found in the fraction of petroleum which distills normally between 135° and 137° C. and was separated from other constituents by physical means. This was accomplished by fractionally crystallizing the distillate, after first extracting it with liquid sulphur dioxide to remove aromatic hydrocarbons. The high viscosity of the oil, at the temperature required for its crystallization (approximately -150° C.) prevented it from crystallizing. Hence, in order to separate the nonanaphthene, it was necessary to crystallize it from solution in solvents of low viscosity. The solvents used were liquid methane and propane and liquid dichlorodifluoromethane.

The determination of the amount of the nonanaphthene in Oklahoma petroleum must await the completion of

the analysis of the distillate boiling immediately above it. However, it is safe to conclude that the crude oil contains not more than 0.1 percent of this compound.

#### PERMEABILITY OF SYNTHETIC FILM-FORMING MATERIALS TO HYDROGEN

The permeability of film-forming materials to hydrogen is of practical importance in connection with the development of balloon and gas-cell fabrics for rigid airships. The development in the past has been largely empirical, and the materials that have been utilized have been of natural origin, such as rubber and goldbeater's skin. Why some materials have low permeabilities and others high has been obscured by the indefinite and complex nature of the natural materials. The field of synthetic film-forming materials, comprising cellulose and its derivatives, resinous plastics, and synthetic rubber substitutes, not only offers a promising source of new impermeable substances, but, owing to the present-day knowledge of the mode of formation and molecular structure of these materials, they afford an opportunity for the correlation of permeability and composition.

As described in RP750 in the December number of the Journal of Research, measurements were made at the Bureau of the permeability to hydrogen of such materials when spread on balloon cloth, and a correlation with chemical composition was attempted. Low permeability to hydrogen was found for those materials rich in hydroxyl groups, such as regenerated cellulose sheet and polyvinyl alcohol. The low values obtained with polyvinyl acetal and the polyhydric alcohol polybasic acid resins were likewise attributed to the presence of hydroxyl groups in the molecule. The high permeability to hydrogen of cellulose ester and rubber films accords with the relatively high solubility of hydrogen in simple esters and hydrocarbons. As a whole, a rough correlation was indicated between the permeability to hydrogen of the films studied and the solubility to hydrogen of analogous compounds of simple structure. That the presence of hydroxyl groups is, however, not necessarily a requisite for low permeability is indicated by the low value obtained with films containing, for example, polyethylene sulphide.

From a practical point of view, the comparison of the permeabilities shows why, in the construction of gas-

cell fabrics, materials which readily absorb moisture have been used so extensively. For numerous reasons, particularly the variation in weight with changes in humidity, such materials are admittedly undesirable. The comparatively low permeabilities obtained with several materials which are less affected by moisture indicate that a more suitable material may be possible.

#### PHOTOELASTIC PROPERTIES OF SOFT, VULCANIZED RUBBER

Transparent rubber is one of a number of materials which when stressed exhibit the phenomenon of double-refraction. When a sheet of transparent rubber is stretched and is examined by means of polarized light it is crossed by a beautiful display of colored bands. The direction, number, and color of these bands are related to the direction and the magnitude of the stresses in the rubber. Important applications are made of this photoelastic effect in connection with various materials other than rubber; for example, it is used to find the strains in optical glass, and is employed to indicate stresses in models of bridges and dams made of bakelite or celluloid. Rubber, however, has not been employed in such studies, although it is the only material available for photoelastic work which can be stretched to any great extent. When a photoelastic study was undertaken using a rubber model, data which were needed regarding the photoelastic constants were not available. An investigation, described in RP751 in the December Journal of Research, was therefore undertaken for the purpose of obtaining accurate measurements on the relative retardation per unit thickness and a related magnitude, the stress-optical coefficient.

Transparent rubber compounds of a number of typical compositions were examined, and values of the coefficient of retardation and the stress-optical coefficients were found for samples of each composition when subjected to relatively wide ranges of stress. The results obtained were very concisely and accurately expressed by simple equations, one for each compound. The constants of these equations, in turn, were related to the composition of the rubber. In the case of rubber-sulphur compounds, the relation depended simply on the combined sulphur content, and all measurements on these compounds could be expressed by a single equation.

**THE FABRICATION OF SILVER CHEMICAL EQUIPMENT**

As a part of a survey of existing and potential uses of silver made under a research associateship established at the National Bureau of Standards by a group of American silver producers, the field of silver chemical manufacturing equipment has been studied. An item on page 92 of Technical News Bulletin No. 210 (October 1934) covered the resistance of silver to corrosion by various agents. The methods of fabricating silver equipment are now being studied, as well as the properties of silver which are of special interest in this connection.

Silver has the highest electrical and thermal conductivities of any of the metals. Its softness and ductility are well known. Equipment which requires the use of silver may either be made entirely of fine silver or it may be lined by one of three methods: by fitting in thin silver linings, by electroplating, or by using a duplex material.

Fine silver equipment is the simplest to construct and is much used. It offers the advantage of easy reclamation of the silver when the equipment has served its useful life, since it does not have to be separated from another metal. The comparatively low strength of silver is a serious disadvantage for work at high pressure, particularly if the temperature is also high.

A common method of lining a piece of apparatus with silver is simply to fit silver sheets or other fabricated forms of silver snugly inside a shell of a base metal. The space between the lining and outer shell is made as small as possible by hammering the silver lining tightly against the casing. Such equipment is very serviceable and the silver can be easily reclaimed. The heat transmission of such apparatus is relatively poor.

Electroplated vessels of large size have been made, but considerable care is necessary in doing the plating work if an impervious coating is to be obtained.

Duplex material consisting of silver joined to a base metal—for example, a bimetallic sheet—has been used for small pieces, and interest is developing in the possibility of using this method in larger construction.

Silver can readily be soldered with either soft or silver solder. It can also be welded. When the sheets of silver are thick, the welding process may be carried out in much the same

manner as in welding steel. Some operators use a flux while others prefer to weld the bare metal.

**DETERMINATION OF COMBINED OXYGEN IN STEEL**

The importance attached by steel metallurgists to the project under way at the Bureau concerning the reliability of methods used for the determination of combined oxygen in steel is attested by the recent approval by the Iron and Steel Institute of Great Britain. Five research laboratories in that country have recently been encouraged by that Institute to participate in this cooperative study. This brings the number of cooperating foreign laboratories to 17, the total number engaged in the work being 37.

**STRUCTURE OF WELDED STAINLESS STEEL**

Welding of stainless steel of the "18-8" type (18 percent chromium and 8 percent nickel) often results in a structural change, usually considered to be detrimental, wherein carbides are formed within and around the constituent grains. The use of certain metallographic etching methods for revealing this condition is frequently included in specifications, electrolytic etching in a solution of sodium cyanide being a common method. This method, although superior to most others, has a number of drawbacks. A new method recently used by the Bureau in a study of the changes induced in special alloy steels upon welding promises to be far superior to all others. This consists in etching electrolytically in oxalic acid (10 g in 100 ml of water), the specimen being the anode and a piece of platinum the cathode. The current from 3 standard dry cells in series or from a 6-volt storage battery serves to reveal carbides in the metallographic structure in 15 to 30 seconds and the grain structure on etching about 30 seconds longer. The solution does not stain the specimen, a drawback of almost all other methods.

**GRAIN STRUCTURE OF STEEL WIRE**

Application of the McQuaid-Ehn carburizing test to specimens of heat-treated steel wire that failed in suspension-bridge cables under low load showed that the steel did not respond uniformly. Both "normal" and "abnormal" steel were present in the wire. Although no one piece of wire was found that was entirely normal

or abnormal as judged by the austenite grain size of completely carburized specimens, small sections were predominantly of one type or the other. The results of the McQuaid-Ehn tests indicate that wire showing low ductility when fractured under tension is predominantly "normal"; that is, the grains of austenite (the high-temperature form of steel) are large, whereas wire with normal ductility had fine-grained austenite, or is "abnormal."

#### INSPECTION OF TIP OF WASHINGTON MONUMENT

Advantage was taken recently of the scaffolding and other arrangements which have been made for the cleaning of the Washington Monument to inspect the aluminum pyramid which forms the tip of the Monument, 555 feet above the ground. This inspection was made, at the request of Hon. Sol Bloom, Director of the George Washington Bicentennial Commission, by metallurgists from the Bureau and from the Aluminum Company of America. Aside from slight damage to the extreme tip of the aluminum cap by lightning, the aluminum was found to be in a remarkably well-preserved state. The surface of the cap was darkened by a thin gray oxide coating, which could be easily scraped off so as to expose the smooth silvery-bright metal surface beneath. The engraved inscriptions recording the placing of the cap 50 years ago (December 6, 1884) appeared as sharp and clear-cut, after the oxide coating was removed, as if they had been finished only a relatively short time ago.

#### ULTRAVIOLET TRANSMISSION CHANGES IN GLASS

Continuing the research previously reported in BS J. Research 3, 629 (1929); RP113, further consideration has been given to methods of testing the photochemical stability of window glass intended to transmit short wave length ultraviolet solar radiation. In RP744 in the December Journal it is shown that accelerating the stabilization of the transmission of window glass (equivalent to the stabilization produced by sunlight) by means of filtered ultraviolet radiation from the quartz mercury arc is impracticable principally because of the antagonistic action of radiation of wave lengths in the region of about  $365m\mu$ , which reverses, in varying degrees, the photochemical reaction produced by the shorter wave lengths.

A new phenomenon in the ultraviolet transmission behavior of certain glasses is reported. The phenomenon may be briefly described as follows: When irradiated with light of a given wave length (in the region  $250m\mu$  to  $365m\mu$ ), the sample of glass reaches an equilibrium state in which the transmission (at  $302m\mu$ , for example) attains a certain value, which is a constant for the given wave-length stimulus. The equilibrium value of the transmission is different for each wave length of the radiation stimulus, increases with increasing wave length of the stimulus, and is independent of the previous order of treatment of the glass.

In place of a chemical analysis, the absorption spectrum (which is a characteristic of every chemical compound) is used as a criterion for judging the magnitude of photochemical action produced by ultraviolet radiation of different wave lengths of homogeneous radiation.

In the soda-lime-silica glasses examined (whether or not they contained an appreciable amount of iron oxide) the photochemical equilibrium was found to be different for each wave length of homogeneous radiation to which the glass reacts. To attain this equilibrium, the reaction caused by a given wave length is in the direction either to increase or to decrease the transmission, depending upon the existing chemical condition developed by previous heat treatment or by previous exposure to other wave lengths to which the glass reacts.

Using homogeneous radiation, no wave length (at least not for wave lengths shorter than and including  $365m\mu$ ) was found that has the exclusive property of either increasing or decreasing the ultraviolet transmission in the soda-lime-silica glasses examined.

The longest wave length having an appreciable photochemical action on a soda-lime-silica glass is at about  $405m\mu$ . For wave lengths  $365m\mu$  and shorter, the photochemical action, as determined by the equilibrium levels in spectral absorption, is a function of the wave length (the frequency) of the radiation stimulus; the shorter the wave length, the greater the photochemical action in the direction of greater absorption.

In contrast with a soda-lime-silica glass, a phosphate-lime glass (containing oxides of Al, B, Mg, Na, Si, and Fe as minor constituents) is depre-

ciated in ultraviolet transmission only by wave lengths shorter than about  $290\mu$ . After depreciation, the ultraviolet spectral transmission curve of the calcium phosphate glass is similar to that of a soda-lime-silica glass. Nevertheless, the exposure of the depreciated calcium-phosphate glass to homogeneous radiation of wave lengths 297 to  $365\mu$  does not appreciate the transmission, as obtains in a soda-lime-silica glass. In other words, in contrast with the soda-lime-silica glass, certain wave lengths have the property of decreasing the ultraviolet transmission, but in the spectral range investigated no reverse reaction was observed.

As the result of observations on samples of pure, relatively iron-free glass prepared by A. N. Finn, of this Bureau, it has been found that soda-lime-silica and soda-silica glasses are unstable photochemically, while potash-lime-silica glass is not appreciably affected by ultraviolet radiation. It, therefore, appears that soda is the photosensitive constituent in a soda-lime-silica glass.

#### ELASTICITY OF REFRACTORIES

In recent years it has been pointed out that the modulus of elasticity of certain ceramic products bears an important relation to their life when such products are subjected to repeated thermal shock. Furthermore, it has been shown that the modulus changes with temperature. When a finished ceramic product undergoes a rapid change in temperature, also referred to as thermal shock, there are great differences in temperature within the article. The stresses set up between two points in the article depend on differences in temperature and properties of the material, especially on the modulus of elasticity, and coefficient of expansion. An investigation was therefore undertaken to determine Young's modulus of elasticity of refractories at  $20^\circ$ ,  $100^\circ$ ,  $200^\circ$ ,  $300^\circ$ ,  $400^\circ$ ,  $500^\circ$ ,  $600^\circ$ ,  $700^\circ$ , and  $800^\circ$  C. The specimens were tested in flexure.

Ten brands of fire-clay bricks covering a wide range in silica content (48 to 82 percent silica), 2 brands of silica bricks (96 percent silica), and a high-alumina brick (16 percent silica) were selected and their elasticities determined. The effects on the modulus of elasticity of the pyrometric cone equivalent and porosity and the form or forms of uncombined silica were also studied.

It was found that, with one exception, the modulus of elasticity was affected significantly by the temperature. For 5 brands the modulus increased gradually between  $20^\circ$  and  $500^\circ$  C. and rather abruptly between  $500^\circ$  and  $600^\circ$  C.; for 4 other brands the increase was gradual between  $20^\circ$  and  $600^\circ$  C.; for the 2 brands of silica bricks the modulus decreased from  $20^\circ$  to  $175^\circ$  C. and increased from  $175^\circ$  to  $600^\circ$  C. The decrease of the modulus in the lower temperature range was noted also in highly siliceous fire-clay brick. The modulus of the high alumina brick remained constant to  $400^\circ$  C., then increased gradually to  $600^\circ$  C. In every case the maximum modulus of the refractories was found at or below  $700^\circ$  C.

There is an approximate direct relation between percentage increase in modulus of elasticity from room temperature to  $600^\circ$  C. and the silica content, and also the total linear thermal expansion, provided the bricks are of approximately the same refractoriness and have not been heated sufficiently high to dissolve the silica.

A more complete account of this investigation appears as RP747 in the December number of the Journal of Research.

#### ANALYSIS OF FELDSPAR

Feldspar, a mineral composed essentially of silica, alumina, and the oxides of sodium and potassium, and in addition varying small amounts of minor constituents, is of importance for the part it plays in the manufacture of numerous articles of commerce. Glass in its many forms, porcelain ware for both electrical and chemical purposes, chinaware and ornaments, and enamels for many different purposes are but a few of the manufactured products in which different grades of feldspar find use as an ingredient.

The methods commonly used for the chemical analysis of feldspar require an excessive amount of time, particularly if the analysis is to be used only for grading the material, and great accuracy is not essential. More rapid methods have recently been developed at the Bureau, for the determination of alumina, calcium oxide, and the alkalis. In these, alumina is determined by precipitating with 8-hydroxyquinoline in acid solution and then titrating an acid solution of the precipitate. Calcium oxide is determined by precipitating with oxalic acid without prior removal of aluminum, and then titrating with standardized potassium permanganate. The alkalis

are weighed as chlorides and potassium oxide is determined by separation and weighing in the form of its triple acetate. Optional methods may be used for decomposing feldspar by acid instead of by fusion.

#### COMPRESSIVE STRENGTH, YOUNG'S MODULUS OF ELASTICITY AND POISSON'S RATIO OF KEENE'S CEMENT

Keene's cement is anhydrous calcined gypsum obtained by heating gypsum to about 1,000° C. The time of set of this dehydrated product is then accelerated by the addition of other materials.

In the course of an investigation of concrete, information was desired on the elastic properties of Keene's cement. Since no reliable data could be found, measurements were made of the lateral and longitudinal deformations under a compressive load on four prisms of the material. The wet mix contained 39 percent water by weight of Keene's cement. The prisms were 4 by 4 by 8 inches and they were cured for about 21 days at 37.7° C. Measurements of the deformations under load were made with Tuckerman's optical strain gages having a gage length of 2 inches.

The averages values of the secant modulus of elasticity, Poisson's ratio, and the compressive strength were:

Compressive stress	Modulus of elasticity	Poisson's ratio
lb./in. <sup>2</sup>	lb./in. <sup>2</sup> × 1,000,000	
500	2.03	0.25
1,000	1.99	.25
1,500	1.95	.26
2,000	1.89	.26
2,500	1.84	.27
3,125	1.68	.29

Compressive strength, 4,420 lb./in.<sup>2</sup>

#### COMMERCIAL MASONRY CEMENTS

Information on the properties of masonry cements being very meager, or at least, in general, not comparable, an investigation described in the *Journal of Research for December (RP746)* was initiated. Forty-one commercial masonry cements were studied with respect to chemical composition, fineness, weight per unit volume, volumetric flow of the neat pastes, and bulk specific gravity, while mortars made from those cements were studied with respect to resistance to deformation, water-retaining capacity, volume yield, linear changes, compressive and transverse strength, du-

rability when subjected to cycles of freezing and thawing, efflorescence, and absorption.

It was found that the cements could be classified as hydraulic limes, hydrated limes, natural cements, blast-furnace-slag cements containing various additions, several cements whose composition could not be positively determined, or portland cements with and without admixtures, the quantities of which varied from small amounts to amounts larger than the quantity of portland cement. About half of those studied contained water-repellent additions.

The weights per cubic foot of the dry cement varied from 39.7 to 89.9 pounds.

The amount retained on a no. 450 sieve when the cements were worked through the sieve with kerosene varied from 11.3 to 49.7 percent.

The bulk specific gravity of the neat pastes varied not only because of the different specific gravities of the cements but because of the air emulsified during mixing. Cements containing water-repellent additions appeared to contain the most air. The bulk specific gravity of pastes gaged to an 8-inch spread in the neat spread tests varied between 0.83 and 1.93. Stirring resistance and water-retaining capacity were measured on the masonry mortars.

Cement-sand mortars of 1:3 by dry-rodded volumes produced from 3.3 to 4.2 volumes of mortar per volume of dry-rodded cement. The variation was caused by the variation in weight per cubic foot of the dry cement and by the amount of air incorporated during mixing.

The range in compressive strength of the mortars aged 28 days was from 50 to 3,650 lb./in.<sup>2</sup> There was a sufficient relation found between modulus of rupture and compressive strength to warrant the use of the latter as a measure of the former.

The durability of the hardened specimens (1 by 4 by 6 in.) of the mortars when subjected to freezing and thawing may be predicted with reasonable accuracy by the time required for the specimens to attain 90 percent of their 72-hour absorption when immersed completely in water. The rate of capillary rise when the same size specimens were placed vertically in  $\frac{1}{2}$  inch of water is also a gage of the resistance to freezing and thawing. In 59 of 71 cases those mortars with a rise of 2 inches in 3 hours or less failed in less than 10 freezing and thawing cycles. Of those with a 2-

inch rise in 1 hour or less, all failed in 10 cycles.

Again the strength is also a gage of resistance to freezing and thawing. For example, specimens made from a mortar (1:3 by volume using mixed Ottawa sand) aged 28 days in the damp closet, which failed in 10 or less cycles of freezing and thawing, had compressive strengths less than 400 lb./in.<sup>2</sup>. Only two having strengths less than 400 lb./in.<sup>2</sup> resisted more than 100 cycles. Very few specimens failed in freezing and thawing between 10 and 300 cycles.

Efflorescence was studied by allowing the 1 by 4 by 6 inch specimens to stand on end in  $\frac{1}{2}$  inch of water for about 1 year. Maximum efflorescence developed in approximately 3 months. Composition of the cementing material seems to be the greatest attributive factor for efflorescence. All cements classed as natural or mixtures of portland and natural cements effloresced. Water-repellant additions did not appear always to prevent efflorescence.

#### NEW AND REVISED PUBLICATIONS ISSUED DURING NOVEMBER 1934

##### Journal of Research<sup>1</sup>

Journal of Research of the National Bureau of Standards, vol. 13, no. 5, November 1934 (RP nos. 729 to 742, inclusive). Price 25 cents. Obtainable by subscription.

##### Research Papers<sup>1</sup>

(Reprints from the July, August, and September Journal of Research)

RP696. Corrosion of ferrous metals in acid soils; I. A. Denison and R. B. Hobbs. Price 5 cents.

RP700. Dependence of sound absorption upon the area and distribution of the absorbent material; V. L. Chrisler. Price 5 cents.

<sup>1</sup> Send orders for publications under this heading only to the Superintendent of Documents, Government Printing Office, Washington, D. C. Subscription to Technical News Bulletin, 50 cents per year; Journal of Research, \$2.50 per year (United States and its possessions, Canada, Cuba, Mexico, Newfoundland, the Philippines, and Republic of Panama); other countries, 70 cents and \$3.25, respectively.

RP704. Equipment for measuring the reflective and transmissive properties of diffusing media; H. J. McNicholas. Price 5 cents.

RP706. Colloidal nature and related properties of clays; W. W. Meyer. Price 5 cents.

RP707. Prolonged tempering at 100° C. and aging at room temperature of 0.8 percent carbon steel; G. A. Ellinger and R. L. Sanford. Price 5 cents.

RP708. Influence of oxide films on the wear of steels; S. J. Rosenberg and L. Jordan. Price 5 cents.

RP714. Drift of magnetic permeability at low inductions after demagnetization; R. L. Sanford. Price 5 cents.

#### Technical News Bulletin<sup>1</sup>

Technical News Bulletin No. 211, November 1934. Price 5 cents. Obtainable by subscription.

#### OUTSIDE PUBLICATIONS<sup>2</sup>

Osgood, W. R., Discussion: Stresses in space structures. Proc. Am. Soc. Civil Eng. (33 West 39th St., New York, N. Y.), 60, 1085 (September 1934).

Osgood, W. R., Neutral axis in a reinforced concrete member subjected to combined stress. Civil Engineering (33 West 39th St., New York, N. Y.), 4, 546 (October 1934).

Bowker, R. C., and Wallace, E. L., Effect of temperature on the deterioration of leather containing sulphuric acid. J. Am. Leather Chem. Assn. (Ridgway, Pa.), 29, 623 (November 1934).

Groesbeck, E. C., and Walkup, H. H., The Preece test (copper-sulphate dip) for zinc coatings. The Metal Industry (London, England), 45, 393 and 440 (October 26 and November 9, 1934).

<sup>2</sup> Send orders for publications under this heading only to the Superintendent of Documents, Government Printing Office, Washington, D. C. Subscription to Technical News Bulletin, 50 cents per year; Journal of Research, \$2.50 per year (United States and its possessions, Canada, Cuba, Mexico, Newfoundland, the Philippines, and Republic of Panama); other countries, 70 cents and \$3.25, respectively.

<sup>3</sup> These publications are not obtainable from the Government. Requests should be sent direct to publishers.

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